Exploration Capabilities

Ka-Band Objects: Observation and Monitoring (KaBOOM)

Canceled Technology Project (2011 - 2019)

Project Introduction

NASA has embarked on a path to implement a high power, higher resolution radar system to:

•Track Near Earth Objects (NEOs)- asteroids and comets -100,000 times more accurately than optical telescopes, as part of a system to defend the Earth from major impacts.

•Characterize the size, shape, spin rate, and surface properties of these NEOs to determine which are suitable for eventual visits by crews or mining companies.

•Track orbital debris to ensure crew and spacecraft safety.

The path to the high power radar will take evolutionary steps to lead to the revolutionary capability. The first step is KaBOOM.

NASA is pursuing a demonstration of coherent uplink arraying at 7.145-7.190 GHz (X-band) and 30-31 GHz (Ka-band) using three 12m diameter commercial off-the-shelf (COTS) antennas separated by 60m at the Kennedy Space Center in Florida. In addition, the Agency has demonstrated uplink arraying using up to three 34m antennas separated by ~250m at the Goldstone Deep Space Communication Complex in California and at X-band 7.1 GHz incorporating *real-time correction for tropospheric phase fluctuations*. Such a successful demonstration would then enable NASA to design and establish a high power, high resolution, 24/7 availability radar system for

1. tracking and characterizing observations of Near Earth Objects,
2. tracking, characterizing and determining the statistics of small-scale (≤10cm) orbital debris,
3. incorporating the capability into the Agency's space communication and navigation tracking stations for emergency spacecraft commanding in the Ka-band era that NASA is entering, and
4. fielding capabilities of interest to other US government agencies.

The Ka-band radar offers the possibility of high range resolution (5 cm) and high spatial resolution, also 5 cm for orbital debris in geosynchronous orbit (GEO) around the Earth (about 22,000 miles above the surface). The project will consist of three phases or evolutionary steps that will lead to the new revolutionary capability. The beginning is KaBOOM.

KaBOOM: Space communication system at 8 and 30 GHz, currently in development at Kennedy Space Center, as the prelude to a high power radar array. Will demonstrate phased array uplink of widely spaced antennas with real time compensation for atmospheric phase fluctuations.

KARNAC (Ka band Array Radar for NEO Accurate Characterization): KaBOOM will be transformed to a phased array radar demonstration facility. Each antenna will have a Transmitter of 25 kW peak power in the 34-36 GHz

Ka-Band Objects: Observation and Monitoring Project: Current Array Configuration of Three 12m Reflector Antennas at the Kennedy

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range. The total combined uplink power will be ~ 225 kW.

The capabilities for Ka-Band communications and radar demonstrated by KaBOOM and KARNAC will inform future plans for development of much larger arrays

Anticipated Benefits

High resolution tracking and characterization (size, shape, spin, porosity) of Near Earth Objects.

The Ka-band radar offers the possibility of high range resolution (5 cm) and high spatial resolution, also 5 cm for orbital debris in geosynchronous orbit (GEO) around the Earth (about 22,000 miles above the surface).

Planetary Defense: part of a plan to avoid impacts by asteroids and comets

The goal of KaBOOM is to prove technologies that will allow future systems to characterize Near Earth Objects in terms of size, shape, rotation/tumble rate and to determine the trajectory of those objects. Radar studies can determine the trajectory 100,000 times more precisely than can optical methods.

Current NASA radar systems are limited in both resolution and the distance at which they are effective. KaBOOM is the penultimate, low-cost step before proceeding with a high-power, high-resolution radar system.

For geolocation applications, measurement of atmospheric fluctuations coupled with other sensor data has the potential to increase the accuracy and precision of ground-based target location.

For space communication purposes, the wider spectrum allocation (10x wider than at X-band) will allow for more data to be sent at a given time.

For radio science, the 100-1000x increase in possible uplink power will allow for more precise determination of planetary properties.

Space Domain Awareness (SDA):

Detailed simulations of the capabilities of a phased array radar system indicates that current gaps in the following areas of SDA knowledge can be addressed

- **Detect/Track/Identify**: Uncued detection, Unexpected maneuvers

Discriminate between closely spaced objects

- **Characterization**: Orbital Debris, Satellite break-ups, collisions
- **Threat Warning and Assessment:** Conjunction assessment, Re-entry prediction

Organizational Responsibility

Responsible Mission Directorate:

Exploration Systems Development Mission Directorate (ESDMD)

Lead Center / Facility:

Kennedy Space Center (KSC)

Responsible Program:

Exploration Capabilities

Project Management

Program Director:

Christopher L Moore

Project Manager:

Robert G Brown

Principal Investigator:

Bernard J Geldzahler

Co-Investigators:

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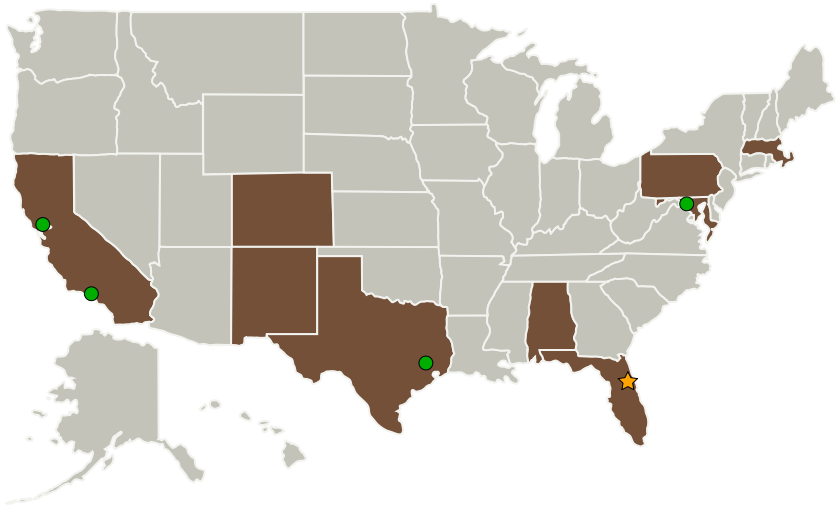
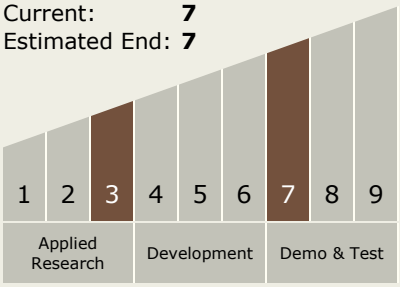
A Ka band system using coherent uplink arraying techniques and bistatic and multistatic radars can meet and probably exceed the goals or, at the very least, compliment a 90 GHz system. Specifically, at Ka-band range resolution of 5 cm and a spatial resolution (using a US-Australia baseline) of ~ 5 cm can be achieved.

Primary U.S. Work Locations and Key Partners



Technology Maturity (TRL)

Start: **3**
Current: **7**
Estimated End: **7**



Technology Areas

Primary:

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  - TX05.6 Networking and Ground Based Orbital Debris Tracking and Management
    - TX05.6.1 Orbital Debris Tracking

Target Destinations

The Moon, Earth

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Organizations Performing Work	Role	Type	Location
★Kennedy Space Center(KSC)	Lead Organization	NASA Center	Kennedy Space Center, Florida
●Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California
Florida Institute of Technology	Supporting Organization	Academia	Melbourne, Florida
●Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland
●Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California
Johns Hopkins University Applied Physics Laboratory(JHU/APL)	Supporting Organization	R&D Center	Laurel, Maryland
●Johnson Space Center(JSC)	Supporting Organization	NASA Center	Houston, Texas
Massachusetts Institute of Technology Lincoln Laboratory(MIT-LL)	Supporting Organization	R&D Center	Lexington, Massachusetts
Sandia National Laboratories(SNL)	Supporting Organization	R&D Center	Albuquerque, New Mexico
Southern Research Institute	Supporting Organization	Academia	Birmingham, Alabama
Texas A & M University-College Station(Texas A&M)	Supporting Organization	Academia Hispanic Serving Institutions (HSI)	College Station, Texas
University of Central Florida(UCF)	Supporting Organization	Academia Hispanic Serving Institutions (HSI)	Orlando, Florida
University of South Florida-Main Campus(USF)	Supporting Organization	Academia	Tampa, Florida

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Co-Funding Partners	Type	Location
Science Mission Directorate(SMD)	NASA Mission Directorate	

Primary U.S. Work Locations	
Alabama	California
Colorado	Florida
Marshall Islands	Maryland
Massachusetts	New Mexico
Pennsylvania	Texas

Project Transitions

October 2011: Project Start

September 2019: Closed out

September 2019: Project canceled because no longer relevant to the mission

Rationale: Project canceled because no longer relevant to the mission

Images

Ka-Band Objects: Observation and Monitoring Project: Current Array Configuration of Three 12m Reflector Antennas at the Kennedy
Ka-Band Objects: Observation and Monitoring Project: Current Array Configuration of Three 12m Reflector Antennas at the Kennedy *(https://techport.nasa.gov/image/40790)*

Ka-Band Objects: Observation and Monitoring Project: During Construction
Ka-Band Objects: Observation and Monitoring Project: During Construction *(https://techport.nasa.gov/image/40792)*